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Complex mat having a ply of volumized fibers

The invention relates to a method for manufacturing a multi-layered mat formed by means of fibers, strands, yarns or twists, a multi-layered mat manufactured according to the method and/or a molded article manufactured therefrom, as well as an apparatus for carrying out the method.

A scrim formed from glass fibers is described in DE 203 10 085 U1. This scrim consists of loosely laid fibers that were not stitched together.

A multi-layered mat of the type mentioned at the beginning is supposed to have a good expandability as well as a large three-dimensional deformability if it is to be used for strengthening hardenable plastics. These mats are, for example, embedded between two mold halves, in accordance with the printed publication EP 0 395 548 B1. After the mold halves have been closed, hardenable resins such as, e.g., unsaturated polyester resins, phenolic resins, epoxy resins are put into the open cavities of the molds by means of injection (pressure) or by infusion (vacuum). The result is a so-called full laminate.

If the central ply of a multi-layered mat consists of a particularly light material, such as foam, this is a so-called sandwich laminate.

Basically, several fiber plies that were inserted individually can be used for pressing in such closed systems. Preferably, however, multi-layered mats as they are known from the printed publications DE 100 51 598 A1 and DE 102 11 175 C1 are being processed. The work flow can thus be simplified and made cheaper.

Multi-layered mats known from the aforementioned prior art have two outer surface plies of cut glass fibers. There is a central ply in the area of the core. The individual plies of these mats are joined together to form a multi-layered mat by means of a stitch-bonding process.

It is important for the function of this multi-layered mat that the central ply, also known as central layer or core layer, behaves elastically and is

capable of providing restoring tension. In that case, this resilient central ply can be made to reliably urge the outer surface plies against the molds. What is achieved by this is that there is no overflooding by non-strengthened resin between the mold and the surface plies, which would affect the functional performance of the manufactured molded article. At the same time, the multi-layered mat is supposed to be expandable so that the material does not tear when subjected to complicated shaping.

Commercially available multi-layered mats comprise a central or core ply of needled or felted plastics monofilaments (e.g. polypropylene, polyester, polyamide, etc.) or of needled or loop-like knit glass fibers. The central ply is covered from both sides with cut fibers for strengthening and joined with them as loosely as possible by means of a stitch-bonding process. This is to ensure the expandability and deformability of the multi-layered mat and the restoring tension of the core material. At the same time, open drainage structures are created due to the existing restoring tension of the core material, i.e. the central ply, the drainage structures affecting as little as possible the venting and filling with liquid resin after the mold is closed.

However, these multi-layered mats, which are on the market and are known from the printed publications DE 100 51 598 A1 as well as DE 102 11 175 C1, and which are on offer, for example, under the name ROVICORE or MULTIMAT, have the disadvantage that the homogeneity of the laminate of the finished molded article is interfered with if filaments of plastic are used for the core ply, because these plastic filaments form a separate separation ply as a foreign body between the actual strengthening fibers. This results in problems regarding the strength of the molded article manufactured therefrom.

If glass fibers that are formed in a loop-like manner are used, there is the problem that the multi-layered mat, also known as complex mat, which is pressed together in the molds, tends to have a substantially higher specific weight than is desired for most articles, due to the large degree compaction of the material.

The embodiments known from the state of the art further have the disadvantage that very large and undesired accumulations of resin occur in the area of the core during low-intensity pressing in the mold, and that, in the event of high-intensity pressing, venting and flow rate are disadvantageously greatly reduced.

From the printed publication WO 02/076701 A1, a multi-layered mat is known in which the volumized strands, yarns or twists of a central ply, which are formed of fibers, differ in the material or the degree of volumization. Good impregnation properties and venting properties at a low resin take-up are supposed to be achieved in this manner.

It is the object of the invention to provide a multi-layered mat as well as molded articles with improved properties manufactured therefrom.

For solving this object, a multi-layered mat is created in which the central ply comprises volumized strands, yarns or twists. Volumized strands, yarns or twists are described in DE 3540537 A1. Hollow-body fillers are deposited between fibers of strands, yarns or twists. In particular, the hollow-body fillers are hollow microspheres that were first inflated by being subjected to heat. To this end, the uninflated precursor of a hollow-body filler is introduced between the fibers, and the material thus obtained is subjected for the required time to the temperature required for the inflation process of the precursor.

The diameter of the hollow-body fillers typically is 20 to 300 μm. The length of the fibers, strands, yarns or twists used lies, advantageously, at 5 - 150 mm.

In the state of the art, volumization is provided in order to be able to set the absorption capacity for liquid hardenable resins to a desired value. In contrast, the present invention pursues and achieves the goal of improving the mechanical properties of a multi-layered mat, that is, in particular to provide for good elastic properties as well as restoring tensions.

In particular, strands, yarns or twists consisting of glass fibers are volumized. In this manner, strands, yarns or twists formed of glass fibers are expanded by several times their original volume. These are now processed into a mulit-layered mat with outer surface plies. The outer surface plies can consist of fibers, that is, in particular of glass fibers, which are connected with the central ply by means of a stitch-bonding process, for example. Preferably, however, the surface plies are also formed of strands, yarns or twists, because the production is simpler in that case.

Production is carried out in a simple and cost-effective manner by placing the individual plies of material in layers using several cutters that are arranged behind one another, and feeding the plies to the stitch-bonding process.

It is a disadvantage of the multi-layered mats available on the market, also known as complex mats, that the needled or knitted central plies, also known as core plies, must be manufactured in a separate machine-driven working process. The multi-layered mat according to the invention can be manufactured in a single process step on a single machine. Therefore, a more cost-effective manufacture is possible in comparison to the prior art.

Surprisingly, it was found that even two-dimensionally arranged fiber strands expanded with elastic hollow microbodies or -spheres have a high elasticity and restoring tension, and, upon being subjected to pressure, generate a high hydraulic counterpressure that is achieved by the deformation of the hollow microbodies. This counterpressure is sufficient to press outer fibers that serve the purpose of strengthening against the walls of the molds. In contrast, mechanical rebound effects only occur in the core plies that are available on the market and are described above, when a part of the needled or loop-shaped knitted fibers or strands, yarns or twists are arranged vertically in the direction of the exertion of the pressure (three-dimensionality). In contrast, the two-dimensional arrangement suffices, surprisingly, in the volumized strands,

yarns or twists, in order to provide, advantageously, a high restoring tension.

A mat used as a central ply can be volumized afterwards. Such mats have been on the market for a time under the name "SPHEREMAT". However, due to the chemical and mechanical fixing at the crossing points, these mats do not have the desired flexibility and expandability of strands, yarns or fibers that lie loosely on top of each other and are needled not until after the volumization. Therefore, the use of such central plies that were provided from strands, yarns or twists that are already volumized is preferable.

In the three-dimensional arrangement of the strands, yarns or twists of the core or central ply of the multi-layered mats available on the market ("ROVICORE", "MULTIMAT", etc.) compressive stresses are generated in the vertical direction, which lead to an unsightly surface of the finished molded article (print effect). If the volumized strands, yarns or twists of a core or central ply are arranged two-dimensionally, these adverse effects on the surface of a manufactured molded article are avoided.

Furthermore, the embedded hollow microspheres reduce the resin consumption by up to 50 %, compared to the aforementioned multi-layered mats that are available on the market. This means a reduction of the specific weight of more than 50 %, in part, in contrast to the complex mats that are available on the market.

A coarse and open structure of the material is created by the hydraulic restoring stress of the hollow microspheres, and despite the random orientation, which is only two-dimensional, of the volumized strands, yarns or twists. This results in advantageous venting and resin drainage properties.

A further advantage in using very light and low-resin volumized strands, yarns or twists, which consist of glass fibers, in the core area of a multi-layered mat is that the result has the characteristics of a full laminate but the weight-reducing properties of a sandwich laminate. In contrast to sandwich laminates that are already available on the market, no ad-

ditional core material of light wood or foam and the like must be worked in separately, when a light, rigid construction is desired for constructional reasons.

Advantageously, both the core ply or central layer as well as the surface plies or surface layers consist of glass fibers. Thus, a product homogeneity can be achieved that is hitherto unequalled. The physical and mechanical properties of the central layer then correspond to the physical and mechanical properties of the surface layers.

Figure 1 shows a section of the central ply in a top view, and figure 2 shows a section of the central layer from a perspective. Spherical hollow bodies 2 are embedded between individual glass fibers 1. The interstices 3 can be filled with impregnating resin. Figure 3 schematically shows the structure of a multi-layered mat. Two surface layers 5 and 6 consisting of non-volumized glass fibers enclose a central ply 4 formed of volumized strands consisting of glass fibers. The fibers in the surface plies 5 and 6 and in the central ply 4 run parallel or at least almost parallel to the surface 7 and are, in that sense, arranged two-dimensionally.

The manufactured complex mat schematically shown in figure 3 consists of cut fibers having a cut length of 5 - 200 mm. The different layers have been connected with each other by a stitch-bonding process. The outer plies 5 and 6 consist of cut glass fibers, and the central ply 4 consists of volumized cut strands that were formed of glass fibers. The central ply 4 can consist of a mixture of volumized strands, yarns or twists and non-volumized glass fibers. Fibers based on carbon, aramid, plastic fibers have proven to be particularly suitable for the volumized ply 4. Then, the outer plies 5 and 6 preferably consist of aramid or carbon fibers. The strands of the central ply are cut after volumization and are then connected with the surface plies by a stitch-bonding process.

An apparatus for carrying out the method is shown schematically in figure 4. Three cutters 9, 10 and 11 are disposed behind one another above a conveyor belt 8. So-called continuous strands, which are not

volumized, are fed to the outer cutters. Volumized continuous strands are fed to the central cutter 10.

A continuous filament is one that is very long and, for processing, is usually reeled off a spool. Such a filament may have a length of tens of meters, up to hundreds of meters.

The cutters cut strands of the desired length from the continuous strands. The cut fibers arrive on the conveyor belt 8 disposed thereunder. The conveyor belt 8 transports the cut fibers that were put above one another in layers to a device 12 that stitches the strands together. The result is the mat shown in figure 3.